RMU2. Therefore, the actual cathodic protection circuit **20** going out of operation can be predicted with a high degree of certainty.

[**0075**] In a preferred embodiment of the present invention, both a pipe-to-soil measurement unit **42** and a pipeline current measurement unit **50** are incorporated into remote monitoring unit **62**. By measuring both pipe-to-soil potential and pipeline current at RMU1 and RMU2 in the example in **FIG. 6**, the certainty of predicting when and which cathodic protection circuit **20** has failed is enhanced significantly.

[**0076**] This monitoring method has a number of benefits associated with it including measuring return current flowing in the pipeline **10** as well as other properties of the pipeline **10**. The return current flowing in the pipeline **10** is an important parameter. The current flow back to a rectifier **24** in pipeline **10** at any particular point is determined by the total amount of current picked up by the pipeline **10** before that point. Pipeline current measuring units are used on pipelines for specific troubleshooting and diagnostic purposes. By including a pipeline current measuring unit **50** at an RMU location, the certainty of predicting which cathodic protection circuit **20** has failed is increased because each cathodic protection circuit switching off will cause a unique change in pipeline current at an RMU location.

[**0077**] Sometimes line current measurement units **50** are installed on either side of a pipeline segment, say 1 mile apart. The difference between the return current measured at each line current measurement unit **50** is then equal to the total amount of current picked up by that 1 mile segment of pipeline **10**. An increase in the total amount of current picked up by the pipeline segment may be indicative of coating degradation or some other CP upset condition such as a short, and an investigation into the cause of the increased amount of current picked up may be initiated. To date, these measurements are carried out manually by actually visiting test station **40** and measuring the line current using line current measurement unit **50**.

[**0078**] As described above, it is preferred not to place remote monitoring units directly at a CP location so that it is possible for one remote monitoring unit to monitor a plurality of cathodic protection circuits **20**. It is preferable that the remote monitoring unit be some distance away from each cathodic protection circuit **20**, so that the remote monitoring unit can determine whether each one of the plurality of cathodic protection circuits **20** is on and operating. Further, the remote monitoring unit can determine whether a particular cathodic protection circuit **20** is maintaining a certain pipe-to-soil potential.

[**0079**] Another advantage is the flexibility in the placement of the remote monitoring unit. As can be seen from **FIG. 6**, RMU1 can monitor CPSs **20***a,b,c* while RMU2 may monitor CPSs **20***b,c,d*. Therefore, each of the remote monitoring units is strategically located so that they can discern current pipeline influences from two or more cathodic protection circuits **20**. Typically in the prior art, a remote monitoring unit is required for each cathodic protection circuit. However, because the remote monitoring units of the present invention may be strategically located, the number of remote monitoring units may be reduced as compared to the prior art. Further, the reduced number of monitoring units can also monitor and measure the current influences of a plurality of cathodic protection circuits **20** as compared to only one prior art cathodic protection circuit. The pipe-to-soil potential at any particular test station may also be influenced by foreign CPs, i.e. rectifiers belonging to and protecting a pipeline belonging to a second company. A further benefit is therefore that it will also be possible under certain circumstances to monitor the effective operation of multiple cathodic protection circuits belonging to different companies.

[**0080**] An inherent benefit of placing a remote monitoring unit away from the cathodic protection circuit **20** is that the entire section of pipeline **10** between the cathodic protection circuits **20** and the remote monitoring unit can be monitored; large upsets in the CP status, other than a cathodic protection circuit **20** going out of operation, are detectable at the remote monitoring unit. For example, an uncoated water line may cross the pipeline **10** and electrical shorts to this foreign line may occur. The electrical shorts may be a significant drain on the available CP current and could manifest as a change in pipe-to-soil at the remote monitoring unit, initiating an investigation. In conventional prior art monitoring units, an RMU at the cathodic protection circuit would not detect this change because of the proximity to the current source, or groundbed, and the condition would only be detected during the annual test station survey. In embodiments when a pipeline current measuring unit **50** is part of the remote monitoring unit, the certainty of detecting and predicting specific upsets is significantly increased.

[**0081**] As described earlier, a remote monitoring unit measures pipe-to-soil potential, but may optionally measure other parameters as well, such as pipeline current. When installed at a rectifier to monitor the proper operation of the rectifier, the voltage and current output of the rectifier may be measured. Additional parameters hereinafter described may also be monitored by an RMU.

[**0082**] Referring now to **FIG. 7**, there is shown a schematic of an RMU configuration suitable for monitoring a number of sensors **70** to **80**. Sensors **70-80** preferably include an output current sensor **70**, a voltage sensor **72**, a pipe-to-soil potential sensor **74**, a sacrificial anode sensor **75**, a pipeline current sensor **76**, a casing-to-soil potential sensor **77**, a hydrocarbon sensor **78**, a leak detection sensor **79**, and a pig detection sensor **80**. The actual measurement is carried out by measurement and control unit **84**, which typically contains volt meters, current meters or other methods of sensing the output from sensors **70** to **80**. Measurement and control unit **84** is preferably interfaced to communications module **64** through any one of or a combination of analog to digital or serial interfaces. Measurement and control unit **84** and communications module **64** may also be one integral unit.

[**0083**] A remote monitoring unit may be installed at sites where AC power **86** may or may not be available. At sites where AC power **86** is available, an RMU can be powered directly from the AC power **86**, or a battery **88** can provide power and the AC power can be routed through a charging circuit **90** to recharge battery **88**. Battery **88** therefore provides back-up power in case of an AC power failure.

[**0084**] If no AC power is available, an RMU can be powered with a long life battery with sufficient capacity that an RMU can operate for a number of years before replacing battery **88**, or a solar panel **92** can be used to recharge battery **88**. Because communication module **64** typically uses the